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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : A61B 5/0255	A1	(11) International Publication Number: WO 92/09232 (43) International Publication Date: 11 June 1992 (11.06.92)

(21) International Application Number: PCT/US91/08905

(22) International Filing Date: 26 November 1991 (26.11.91)

(30) Priority data:
618,297 27 November 1990 (27.11.90) US

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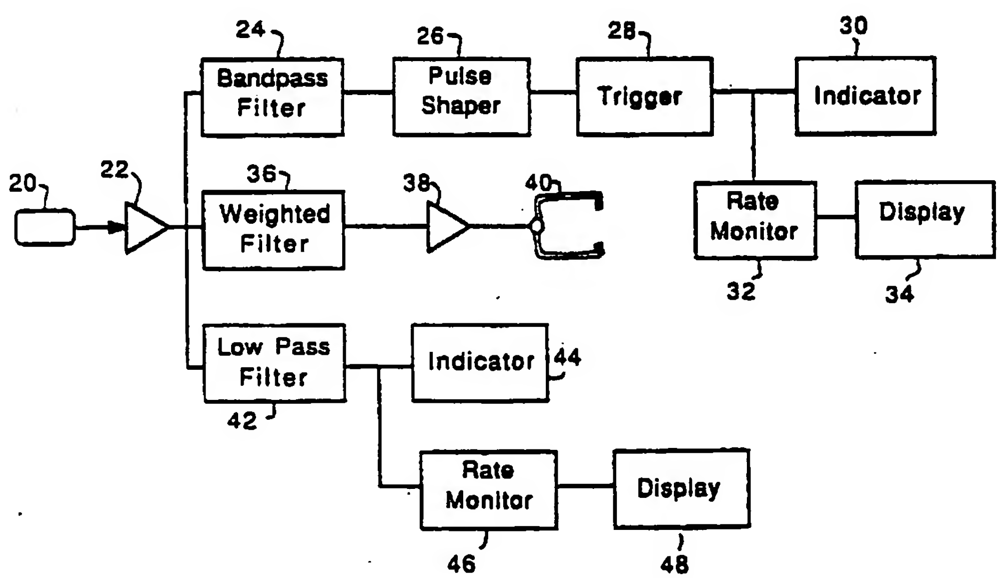
(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).

Published
With international search report.

(54) Title: VITAL LIFE SIGN DETECTOR



(57) Abstract

A vital life sign detector which can be used to determine heart and respiration activity in an individual wearing bulky clothing, such as chemical warfare protective clothing. A detector (20), such as an accelerometer or geophone, detects chest wall vibrations of an individual and produces an output signal (22) in response thereto. The output signal is processed to determine the existence of cardiac and respiratory activity. The output signal can be further processed to calculate the heart rate and respiration rate of the individual. The system produces a visual (34) or audio signal (40) which allows medical personnel to determine quickly whether the individual is alive.

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VITAL LIFE SIGN DETECTOR

Field of the Invention

The present invention relates generally to systems for detecting vital life signs in individuals. More specifically, the present invention provides a method and apparatus for detecting vital life signs, such as heart rate and respiration, in an individual wearing heavy garments or other covering. An example of such an individual would be a soldier wearing arctic clothing or chemical warfare protective gear.

Background of the Invention

The first step in a medical emergency is to determine whether the heart is beating and breathing is present. The heartbeat is classically found by palpating the pulse in the wrist, neck, or ankle, or by listening to the chest with a stethoscope or ear. Breathing is typically detected by observing motion of the chest and abdomen or sensing airflow through the nose and mouth.

Situations occur, particularly in wartime, in which it is not possible for a human to sensorially detect the pulse or breathing. This is particularly true during arctic or chemical warfare where the casualty and the medical personnel may be completely encased in heavy clothing and may be wearing heavy gloves or masks. Blood loss, shock, and trauma may also reduce the intensity of the pulse and respiration which make sensory detection of vital life signs difficult and time consuming.

In situations where large numbers of casualties are present, it is important that care

determining the presence of a pulse and breathing is, therefore, a central issue in casualty management.

The prior art has heretofore failed to provide a system for quickly detecting vital life signs in individuals, such as wartime casualties, who are wearing bulky protective clothing. The vital life sign detector of the present invention, described in greater detail below, fulfills this need.

the Invention

The vital life sign detector of the present invention overcomes the difficulties of the prior art by providing a system which can be used to determine heart and respiration activity in an individual wearing bulky protective coating. In the preferred embodiment of the invention, a detector, such as an accelerometer or geophone, detects chest wall vibrations of an individual and produces an output signal in response thereto. The output signal is processed to determine the existence of cardiac and respiratory activity. The output signal can be further processed to calculate the heart rate and respiration rate of the individual. Numerous types of transducers can be used to detect the chest wall vibrations, including piezoelectric, electromagnetic and resistive transducers.

The system of the present invention is contained in a housing which fits comfortably in the gloved hand of medical personnel and requires little dexterity to activate. The housing also has dimensions which allow it to be stable when at rest on the individual, even when the chest surface is at large angles relative to horizontal. The total mass of the device is sufficient to hold the detector effectively stationary relative to the body of the patient. The bottom surface of the housing is covered with a nonslip coating to prevent sliding off the chest.

of the Drawings

FIG. 1 is an illustration of the vital life sign detector of the present invention placed on an individual.

FIG. 2 is a schematic illustration of the signal processing electronics employed in the vital life sign detector of the present invention.

FIG. 3a is a graphical representation of an ECG signal produced by an individual.

FIG. 3b is a graphical representation of the output signal of the motion detector employed in the present invention.

the Preferred Embodiment

FIG. 1 is an illustration of the vital life sign detector of the present invention placed on the chest of an immobilized individual 12. The detector 10 is provided with an appropriate display to allow the medical aid personnel 14 to quickly determine whether the individual 12 is alive. The beating of the heart and breathing produce movements and accelerations of the individual's body due to changes in organ volume and momentum transfers. These accelerations and movements can be used to provide an indication of cardiac output and respiratory volume changes. The movements range from very low frequencies (respiration: 0.1 to 0.5 Hz; heart rate: 0.5 to 4 Hz) to relatively high frequencies (breath sounds: 100 to 2000 Hz; heart sounds and bruits: 40 to 1000 Hz). These movements and vibrations normally can be detected with the finger or with the aid of a stethoscope applied to the bare skin. However, when clothing or other coupling materials are introduced between the skin and human sensor, the vibrations and sounds are filtered with the high frequency components that are normally sensorially detectable being filtered out. It has been observed by the inventor, however, that the low frequency components are attenuated to a far lesser extent and can be sensed with low frequency acceleration measurement devices. The system of the present invention utilizes these low frequency signals to provide an indication of the existence of vital life signs.

In summary, the vital life sign detector is a small device which, when placed upon a subject, will detect the mechanical vibrations associated with respiratory and heart movement. Typically, the device is placed on the chest of the supine casualty. The medical aid provider removes his hand and observes the face of the device. A display

A second display indicates respiratory motion and displays the respiration rate.

As shown schematically in FIG. 2, the chest wall vibrations produced by cardiac and respiratory motions are detected with one or more motion detectors 20, such as an accelerometer or geophone. The motion detectors 20 can use any of a number of transducers, including, but not limited to, piezoelectric, resistive, or electromagnetic. An example of the typical output signal from the motion detector 20 is illustrated in FIG. 3b. The ECG signal is shown in FIG. 3a for reference. It should be noted that there are two pulses associated with each heart beat. These pulses correspond to the onsets of systole and diastole and are synchronous with the first and second heart sounds.

The signal from the motion detector 20 is first amplified in an appropriate amplifier 22 and then conditioned in several ways. First, for heart rate, the signal is processed by an analog or digital bandpass filter 24 having a pass band from about 0.5 to about 300 Hz. The transient oscillations are converted and smoothed into a pulse by a pulse shaper circuit 26. The shaped pulse signal is then fed to a level sensitive, timed, one shot trigger 28 which is held on for approximately 300 msec before resetting. The lock-on time is consistent with the ejection time of the heart. This time lock-on is to prevent double triggering by the second pulse. The timed pulse is then used to turn on the front panel pulse indicator 30 to provide an indication of the existence of cardiac activity. The timed pulse is also fed to a rate computation means 32, which can utilize analog, digital or software rate computing techniques, known in the art, to calculate heart rate. The calculated heart rate is displayed on a front panel display 34.

to provide a pseudo heart sound output for the user to hear. To provide this signal, the transducer signal is passed through a weighted band pass filter 36 which has a transfer function equivalent to that of a stethoscope. This filtered signal is then fed to a suitable power amplifier 38 which is connected to an earphone 40. In the preferred embodiment of the invention, the earphone is mounted in a stethoscope yoke to facilitate use.

The output signal of the motion detector 20 is also provided to a third channel which is used to determine the existence of respiration in the individual by one of several methods. In one method, the detector signal is processed in an extremely low bandpass filter 42. The high frequency cutoff of the filter 42 is approximately five Hz. The overall detector and filter low frequency cutoff should be 0.05 Hz or less. It is preferable that the low frequency cutoff be defined by the detector rather than the subsequent electronics. High pass filtering should not be used to avoid long settling times resulting from any large artifacts introduced into the signal.

Another suitable method for detecting respiratory movements from the detector signal is to measure the beat-to-beat changes in the intensity of the pulses. The intensity of the pulses are due, in part, to the compliance of the chest within which the heart is beating. The compliance of the chest is dependent upon the volume of air contained within the lungs and the muscle tension of the chest muscle, both of which will change during the course of respiration. The cyclical compliance variations during breathing produce the cyclical variations in the detected pulse amplitudes.

The low frequency components produced by filtering methods or the variations in

Either signal is also fed to a rate computation means which can utilize analog, digital, or software rate computing techniques, known in the art, to calculate respiration rate.

Careful attention to the housing design is required for the detector to operate properly to detect heart beat and respiration through garments. The device should fit comfortably in the gloved hand of medical personnel and should require little dexterity to activate. The housing should have dimensions which allow it to be stable when at rest on the individual, even when the chest surface is at large angles relative to horizontal. The total mass of the device must be sufficient to hold the detector effectively stationary relative to the body of the patient. A rectangular box of 4" x 3" x 1" having a weight of one pound has been found to be a satisfactory upper limit. The bottom surface of the housing should also be covered with a nonslip coating to prevent sliding off the chest. The displays should be large and designed to be easily read especially from low angles relative to the display. Finally, the device package should be sealed against contaminants since, as an emergency device, it will be used in hostile environments.

Although the vital life sign detector of the present invention has been described in connection with the preferred embodiment, it is not intended to be limited to the specific form set forth herein, but on the contrary, it is intended to cover such modifications, alternatives, and equivalents as can be reasonably included within the spirit and scope of the invention as defined by the appended claims.

1. A system for detecting vital life signs in an individual, comprising:

means for detecting vibrations in the chest wall of an individual and for producing an output signal in response thereto, even when said individual is wearing bulky clothing;

means for correlating said output signal with vital life signs of said individual.

vibrations comprising a piezoelectric transducer.

3. The system according to claim 1, said means for detecting said chest wall vibrations comprising a electromagnetic transducer.

4. The system according to claim 1, said means for detecting said chest wall vibrations comprising a resistive transducer.

5. The system according to claim 1, further comprising means for processing said output signal to provide an indication of heart sounds produced by said individual.

6. The system according to claim 5, further comprising means for using said heart sounds to calculate the heart rate of said individual.

7. The system according to claim 6, further comprising a weighted bandpass filter for processing said output signal, said weighted bandpass filter having a transfer function equivalent to that of a stethoscope to provide an electrical signal representation of audible heart sounds, and an audio signal transducer to convert said electrical representation into an audible heart sound.

said output signal to determine the existence of respiration in said individual.

9. The system according to claim 8, further comprising means for calculating the respiration rate of said individual.

10. The system according to claim 1, said system being contained in a housing having sufficient mass to maintain said detector in an effectively stationary position relative to the body of said individual.

A vital life sign detector which can be used to determine heart and respiration activity in an individual wearing bulky clothing, such as chemical warfare protective clothing. A detector, such as an accelerometer or geophone, detects chest wall vibrations of an individual and produces an output signal in response thereto. The output signal is processed to determine the existence of cardiac and respiratory activity. The output signal can be further processed to calculate the heart rate and respiration rate of the individual. The system produces a visual or audio signal which allows medical personnel to determine quickly whether the individual is alive.

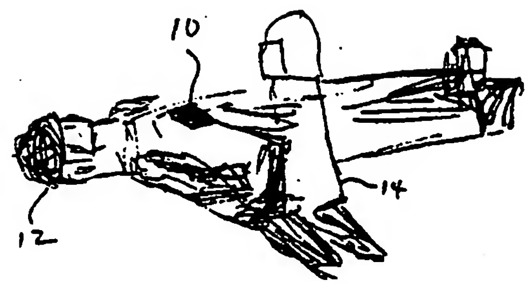
10
12
14

FIG. 1

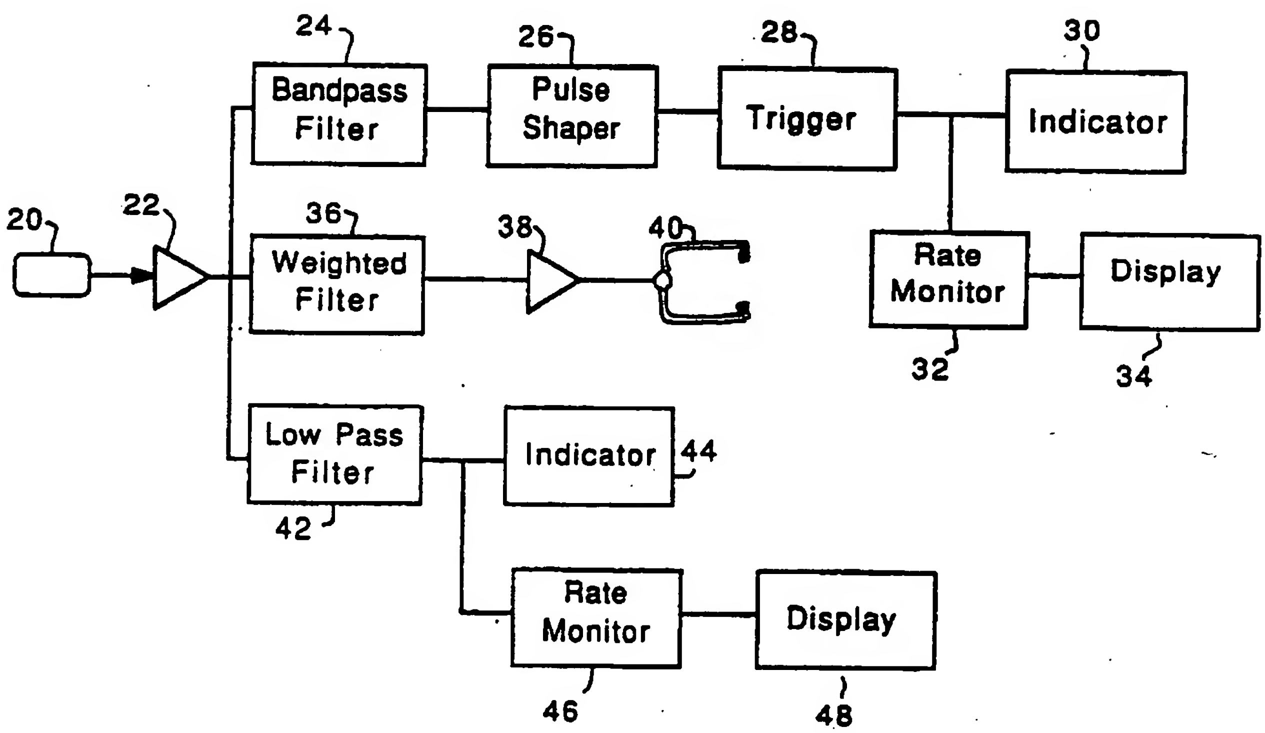
20
22
24
Bandpass Filter
26
Pulse Shaper
28
Trigger
30
Indicator
36
Weighted Filter
38
40
Rate Monitor
32
Display
34
Low Pass Filter
42
Indicator
44
Rate Monitor
46
Display
48

FIG. 2

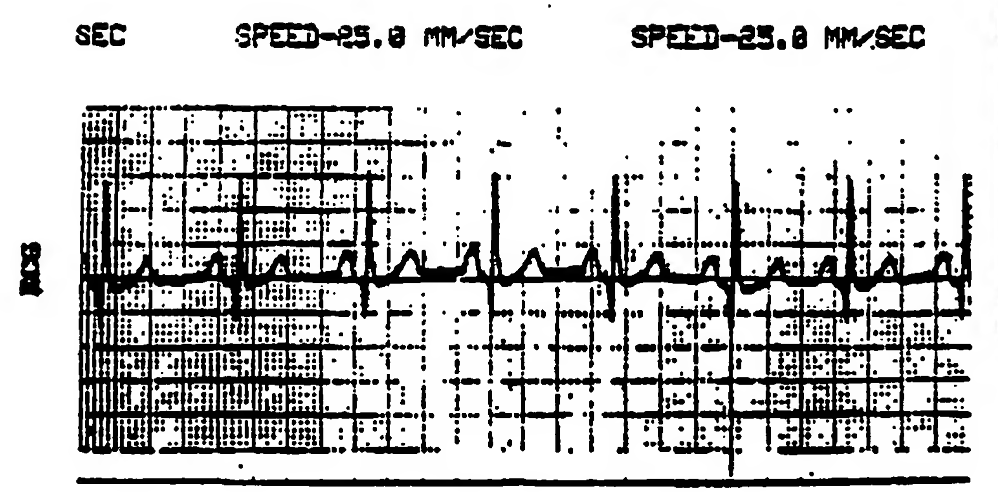
SEC
SPEED=25.0 MM/SEC
SPEED=25.0 MM/SEC
ECG

FIG. 3a

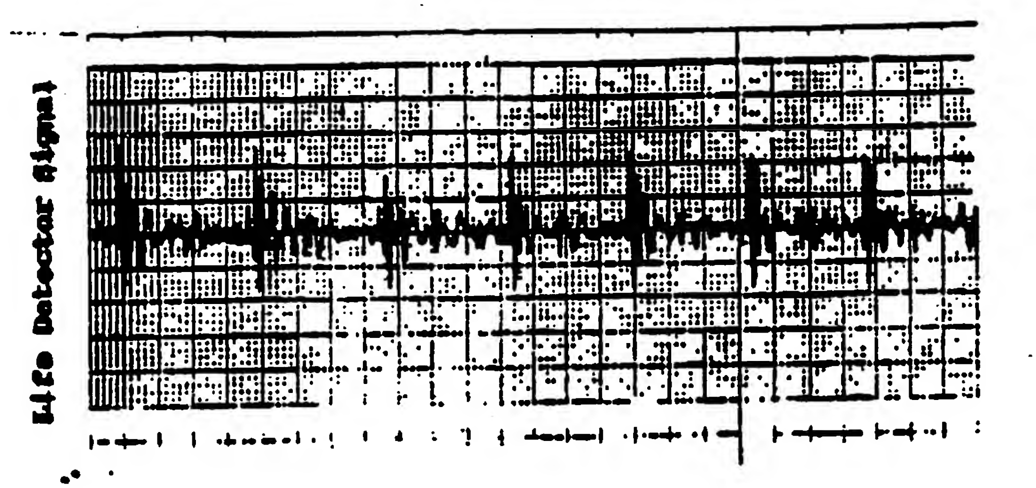
Life Detector Signal

FIG. 3b

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/08905

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): A61B 5/0255
US CL 128/715

II. FIELDS SEARCHED

Minimum Documentation Searched

Classification System	Classification Symbols
US	128/715

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched

III. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X, P / Y	US, A, 5,002,060 (NEDIVI) 26 MARCH 1991 See entire document.	1,2,8-10 / 3,4-7
Y	US, A, 4,840,183 (TAKAHASHI) 20 JUNE 1989 See entire document.	3
Y,P	US, A, 5,010,890 (PFOHL) 30 APRIL 1991 See entire document.	5-7
A,P	US, A, 4,972,841 (IGUCHI) 27 NOVEMBER 1990 See abstract.	1
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IV. CERTIFICATION

Date of the Actual Completion of the International Search: 30 JANUARY 1992

Date of Mailing of this International Search Report: 02 MAR 1992

International Searching Authority: ISA/US

Signature of Authorized Officer: Nguyen Ngoc-Ho

for SCOTT GETZOW NGUYEN NGOC-HO INTERNATIONAL DIVISION

Form PCT/ISA/210 (second sheet) (Rev.11-87)

DC 2/21/92